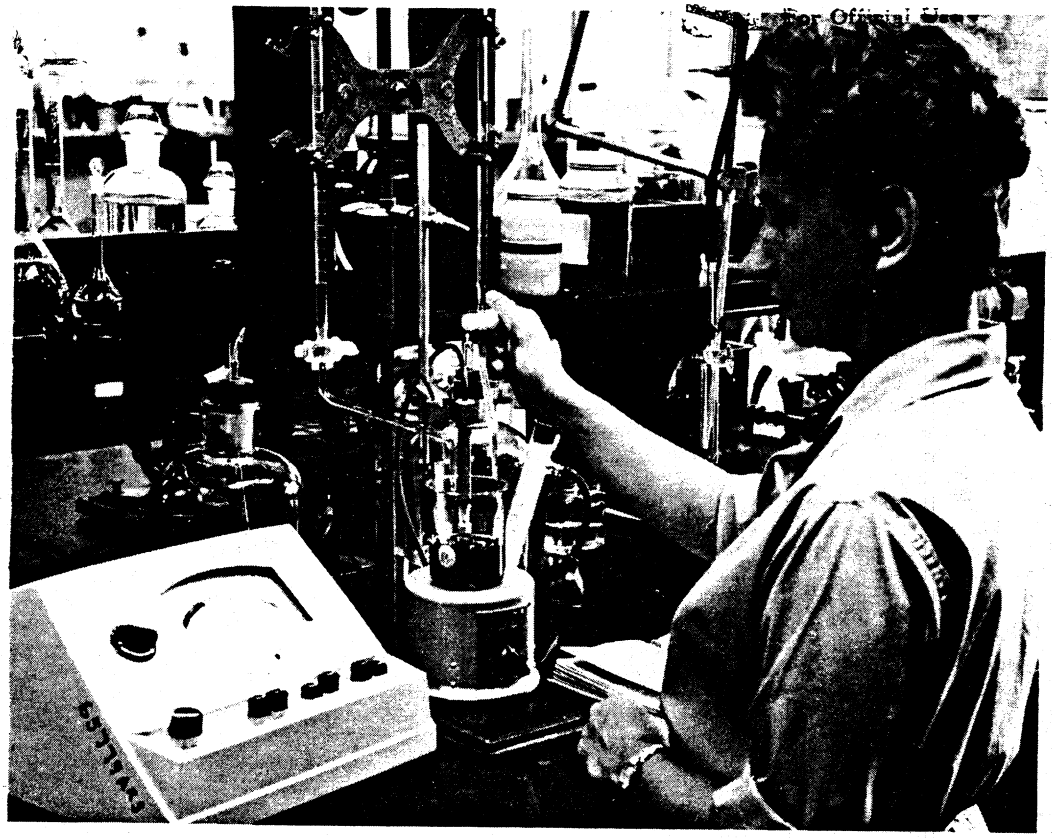

A new procedure for determination of free and total acidity and lactone in honey is run by Irene Kushnir.—Photo by M. C. Audsley, courtesy U.S.D.A.

1586

A Survey of American Honeys

6. Relation of Granulating Tendency to Composition 1/

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1/This is one in a series of articles describing a large-scale study of the composition of honeys from over the United States. Complete data interpretation and conclusions will appear in a forthcoming Department of Agriculture publication.

Number six in a series of ten articles on different honeys of America.

IN THE ANALYTICAL survey of the composition and properties of American honeys which we have carried out over the past three years, we applied a simple test of granulating tendency to the 504 samples that were analyzed.

It was necessary to heat the samples before chemical analysis, either to pasteurize or liquefy them. After analysis the remaining liquid honey sample was stored at room temperature for six months, then examined for the extent of granulation that had taken place. The amount of granulation, from completely liquid to complete hard granulation, was divided into ten classes which were assigned code numbers from 0 to 9. When the results of the analyses of the honey samples were averaged by the IBM computer, these code numbers were also averaged. It is debatable whether such an average number would accurately reflect the granulation tendency of a mixture of the samples being averaged, but since the numbers represent an increasing degree of granulation tendency and this factor depends on composition, much information was gained by this approach.

Honeys Grouped by Granulation Tendency

We collected together all the IBM cards for samples showing the same granulating tendency and the average composition of each group of samples was then computed. In Table 1 we can see the results of this calculation. The most striking features are the increase in dextrose content as granulation tendency increases, and the relative constancy of the levulose values. In some of the remaining columns, a regular trend may be present, and in others there does not appear to be any. In order to decide which of these composition factors actually are different in the different groups, a statistical analysis was made. It was found that all of the following factors change significantly[2/] as the granulation tendency of the honey increases. They are arranged in descending order as far as significance is concerned:

Factor	Change as Granulation Tendency Increases
Dextrose	Increases
Maltose	Decreases
Moisture	Decreases
Higher Sugars	Decreases
Undetermined	Decreases
Sucrose	Increases

Color was found to decrease, but in a less significant manner. None of the other factors varied in any significant manner with granulating tendency.

From the point of view of composition, the most important factor involved in stability of honey on storage is dextrose content. This is logical but not new, since dextrose is the material that granulates out. Non-granulating honeys are higher in "maltose" than rapidly-granulating honeys. This is also logical since the maltose arises from the dextrose in the honey. The moisture content also appears to play a role. A most interesting point arising from this table is that levulose content is not significantly different in any of these groups of honey samples.

Indices to Predict Granulating Tendency

In the past the levulose-dextrose ratio (L/D) has been widely used to re-

2/ Exceeding the F value at the 1 percent probability level by analysis of variance for regression.

late the granulating tendency of a honey to its composition. Several other indices for granulation have been proposed, but none has been shown to be especially useful. The purpose of a granulation index is to allow us to predict the granulation tendency of a honey from its composition.

We have calculated several of these indices from the data in Table 1. Then we determined statistically which of five indices had the most highly significant relationship to the granulating tendency. The one that appears most useful is the ratio of dextrose to water, which was proposed by G. H. Austin of the Canadian Department of Agriculture several years ago. Although he proposed calculating all results to a common moisture content before comparison, we find that this is not desirable since it decreases the sensitivity of the index. Another index proposed by workers at the National Bureau of Standards many years ago [(dextrose-water)/levulose] is as closely related to granulation as Austin's index, but is somewhat more difficult to determine and calculate.

The old levulose/dextrose ratio is much less useful than these. This is expected since the levulose content of the "average honeys" in Table 1 does not vary significantly with granulation tendency.

Relation of Dextrose/Water Ratio and Granulation

The numerical values for the D/W ratio for each class of granulating tendency are given below.

Granulating Tendency	D/W
None	1.58
Few scattered crystals	1.76
1/16"-⅛" layer of crystals	1.79
Few clumps of crystals	1.86
¼"-½" layer of crystals	1.83
¼ of depth granulated	1.99
½ of depth granulated	1.98
¾ of depth granulated	2.06
Complete, soft granulation	2.16
Complete, hard granulation	2.24

These calculations are based on the average compositions of large groups of honey samples, shown in Table 1. They do not give the properties of any actual existing honey samples. It is quite possible that by averaging in this way we have smoothed out individual variations that might be large enough to rob the proposed index of any practical value, that is, of prediction of granulating behavior of individual samples.

Prediction of Granulation Tendency

To find out if such was the case, a statistical examination was made of the relationship of granulation tendency of all samples, individually, with three of the indices, D/W, $\frac{D \cdot W}{L}$, and L/D. This was done on the IBM computer and the results agreed with those we found for the averages, in that the old L/D ratio was much less useful than either of the other two, which were of approximately equal value. The prediction is of course not infallible, but should be useful. It seems reasonable to say that D/W values of 1.70 and lower are associated with non-granulating honey and that values of 2.10 or higher predict rapid granulation to a solid. Intermediate values seem to mean intermediate degrees of granulation tendency.

Caution in Use of D/W Ratio

It must be noted that the use of the D/W ratio is valid only if the dextrose content of a honey is determined by a method giving true dextrose values. Older methods of sugar analysis, in which other sugars are "lumped together" with dextrose will give falsely high dextrose values and therefore high values for the D/W ratio. Such methods include any in which there is no preliminary separation of sugars into classes. This includes the classic polarimetric methods and also hypoiodite methods if used without preliminary separation of sugars.

(Next month--Relation of color to Composition)